Opinion

EMBO reports

Biology, a science of greys

Jordi Casanova

If every event were unique and not related to others, knowledge would not be possible. Given the complexity of life, there is only one way we can learn and understand it: by classifying and by categorising. In doing so, we define models or even archetypes, "perfect examples or models of something". Models and categories are very useful and even indispensable as long as we do not become restrained by them. Once we have established categories and models by generalisation and/or simplification, we need to keep in mind that they correspond to the realm of conceptualisation and not to the realm of life. Indeed, very often, few life phenomena match the definition of archetypes; in fact, most of them correspond to cases that share subsets of features of more than one model. But these cases are not peculiarities or exceptions that we should forcibly adapt to our predefined categories. Instead, the categories or archetypes are tools that we need to adapt to the complexity of life.

But this is something we seem to have forgotten. Many controversies in biology have resulted not from the phenomena of life, but from the categories conceived to encompass them. One case I consider particularly illustrative is the controversy between those who supported the hypothesis that early embryonic development is mosaic versus those in favour of it being regulative. According to the mosaic development hypothesis, each part of an embryo has its particular fate and would generate the corresponding part of the body if developed in isolation. In contrast, the regulative development hypothesis puts forward that the fate of each part of an embryo is determined by interactions with the other parts. As is often the case, all embryos studied to date seem to show features of both models. As mentioned above, this does not rule out the usefulness of models if employed as tools.

A corollary of the above is the need to escape from the conceptual trap of analysing biological phenomena in terms of binary categories, and biological changes in terms of binary decisions or switches. I wonder whether this trend has been increased by the influence of the 0 vs. 1 bit decision-making that underlies computer technology and its influence on our way of thinking.

All of this leads us to the issue of the mechanisms in biology. Not only because we have learnt that different mechanisms can lead to similar outcomes and that the same mechanism can lead to different outcomes, which has fostered the "cellular context" as an almost universal annotation for any discrepancy, but also because of noise. We constantly use analogies that equate living beings to machines. And while this analogy has proved very useful, it carries with it the burden of design. Machines are designed for a defined purpose; living beings exploit non-designed mechanisms for their benefit. Thus, biological mechanisms do not activate or repress a given process upon a null background. Rather, they bias a process in one direction or the other. This is true of many of the mechanisms that regulate cellular metabolism and behaviour, but let us take the regulation of gene expression as an example. Asserting that a trigger activates a given gene means, in fact, that this gene becomes more transcribed than it would be if the trigger were absent; it does not mean, conversely, that this same gene would not be transcribed at all if the trigger were absent. Similarly, asserting that a given mechanism represses gene expression does not mean that the gene is not transcribed at all. Indeed, almost any RNA can be RT-PCR amplified from any given tissue even when it is associated with the differentiation function of an unrelated tissue. In biology, most noise is therefore not the result of a mistake in design, but instead inherent to how a non-designed mechanism was recruited for a given function. Again, this does not mean that mechanisms are not important, just the opposite. It only means they have to be understood in context. In this regard, cellular behaviour is probably more relevant than their precise transcriptome signature. It is worth mentioning that it was Francois Jacob, the co-discoverer of such a sophisticated mechanism as the operon, who reminded us that the living beings are the product of "bricolage" (tinkering) and not of design.

The ensuing conclusion is neither relativism (because, obviously, there are many different shades of grey) nor giving up on classifying and categorising in biology. Indeed, as mentioned at the beginning, classifying and categorising are needed to connect particular events and make it possible to gain knowledge. However, I think our research will certainly benefit if we are more willing to accept multiple, but not necessarily exclusive, explanations for similar facts, and if we do not force the complexity of life to fit the simplicity of models. It would certainly help us to avoid some of the pointless black/white controversies that I feel increasingly jeopardise the advancement of biology.

Institut de Biologia Molecular de Barcelona (CSIC)/Institute for Research in Biomedicine Barcelona, The Barcelona Institute of Science and Technology (BIST), Barcelona, Spain.
E-mail: jcrbmc@ibmb.csic.es
DOI 10.15252/embr.201846332 | EMBO Reports (2018) 19: e46332 | Published online 1 June 2018